APPENDIX I

Wolf River Basin Bird Surveys - 2001

Submitted by Todd Miller, NHI, 2001

Introduction

In 2000, Dennis Kuecherer, Bill Smith, Sumner Matteson and Eric Epstein conducted several bird surveys in the Lower Wolf River Basin for the Natural Heritage Inventory (NHI)'s Biotic Inventory of the Wolf River Basin. In 2001, I surveyed several areas for birds in the Lower Wolf River Basin that had not been surveyed by NHI, including two privately owned tracts (Clark Wetlands for sale in northwest Winnebago County and the Fremont Station Swamp swamp in southeastern Waupaca County) and some floodplain forest in the Navarino State Wildlife Area (SWA) in Shawano County. I also surveyed two stretches of the Wolf River in Waupaca, Shawano, and Outagamie Counties, and the Wolf River Flowage in Navarino State Wildlife Area. I surveyed several areas in the region at night for rails, and accompanied Eric Epstein for two additional morning surveys on the Wolf River.

In all, I recorded 18 element occurrences of 12 species (including a Blanding's turtle). The richest site of those surveyed, in terms of rare birds, appears to be the nearly six square miles of floodplain forest along the Wolf River in Waupaca County south of Shaw Landing, north of Cincoe Lake and east of Partridge Lake. In this area, red-shouldered hawk was detected several times, as well as prothonotary warbler and red-headed woodpecker (see Table 1 for scientific names). Also notable was the number of common moorhen, detected by night surveys in several areas.

Methods

Point Counts

Morning surveys were conducted by point counts on June 4, 6, 21, 22, 2000 at sites selected by NHI Ecologist Eric Epstein. Three of the four surveys were conducted between 5:45- 9:30 AM; a fourth survey was extended to 10:00 AM because of difficult access (a flooded Navarino floodplain forest). NHI Zoologist suggested surveying an older forest stand in Navarino SWA for goshawk. Two additional points were surveyed along County Road K while en route to the Wolf River Flowage and floodplain forest. Points were located a minimum of 250 meters apart. The locations of birds were recorded on field sheets relative to the point center (marked on USGS quadrangle maps) using standardized species acronyms and symbols to record whether they were heard singing or calling, seen perched or flying.

Canoe Surveys

Two stretches of the Wolf River recommended by Eric Epstein were surveyed on June 27 and 28. These were from State Road 156 in Waupaca County to County Road F in Outagamie County, and from Shaw Landing to Gills Landing in Waupaca County. Numbers and species of birds were recorded while paddling or floating down the river. On June 14 and June 15, I accompanied Eric Epstein on surveys of two other stretches of the Wolf River.

Rail Surveys

Rail surveys were conducted at night on June 5, 14, 21, and 26 by playing recordings of vocalizations of each species for 30 seconds, then listening for 30 seconds. Many of these sites were included in 2000 and 2001 rail surveys by interns at Navarino SWA (this data set is appended in the binder).

Miscellaneous Observations

Several element occurrences were recorded while en route from a survey location. One additional element occurrence was recorded while looking for access to the Wolf River for canoe surveys.

Landowner Contact

For the two areas that are privately owned, permission was obtained by phone. Dave Neu, formerly of the DNR Northeast Region, had obtained permission for NHI to survey the Clark/Adolphson property in Winnebago County during the 2000 field season. I contacted the landowner to obtain permission to access the property in 2001. The tamarack swamp in Waupaca has numerous owners. By visiting the area beforehand, I was able to obtain phone numbers of several landowners and permission to access two properties (a log of landowner contact is included in the report binder).

GPS points were taken at a number of sites and are saved as c/data/Todd/birds/Wolf River 2001/wolf river birds 2001-backup.apr

Results

In all, 89 species were encountered, including 21 element occurrences of 12 species (including a Blanding's turtle). Breeding bird survey summary sheets, site survey forms, rare animal field report forms, quad maps, bird point census forms are included in the report binder. Below is a list of element occurrences recorded by site:

EO Sites

Wolf River Flowage (Navarino SWA)

- American bittern
- black-crowned night-heron
- osprey
- black tern

Wolf River Floodplain Forest (Navarino SWA)

- red-shouldered hawk

Wolf River: State Road 156 (Waupaca County) to County Road F (Outagamie County)

- red-shouldered hawk

Wolf River: Shaw Landing to Gills Landing (Waupaca County)

- yellow-billed cuckoo
- red-shouldered hawk
- red-headed woodpecker
- prothonotary warbler
- great blue heron (rookery)
- black tern
- osprey

Egret Pool and Osprey Flowage (Wolf River Bottoms Wildlife Area)

- common moorhen

Pikes Peak Flowage (Navarino SWA)

- common moorhen

DOT Mitigation site (north of Mack SWA)

- common moorhen

State Road 187 at Shawano/Outagamie border

- northern harrier

Weiland's Landing

- Blanding's turtle

Non-EO Sites

Clark Wetlands

- none

Fremont Station Swamp

- none

Navarino SWA older-second growth stand (both sides of K, north of State Road 156)

- none

La Sage Unit (Wolf River Bottoms)

- none; surveyed for rails, only.

Discussion

Nearly 40% of the element occurrences I recorded during the various surveys were along the Wolf River between Shaw Landing and Gills Landing. This stretch of river and the stretch from Gill Landing to Fremont encompass more than 20 square miles of extensive natural communities (Epstein et al. 2000). Since many species of birds such as red-shouldered hawk and prothonotary warbler are sensitive to habitat fragmentation, managing this area as a large unit would maintain these and other rare species that likely occur here.

I detected common moorhens during night surveys at a number of sites. It is likely that king rail occur at some of these sites, too, but I would recommend further surveys to confirm this, since in some cases Virginia rails would respond to the playback of king rail recordings. While I heard all three calls of the Virginia rail during the surveys, I did not hear either of the two calls characteristic of king rail (a third, grunting call is very similar to number to the grunting call of the Virginia rail). Nevertheless, the surveys conducted by interns at Navarino SWA provide data on common moorhen from other sites that are probably reliable.

The High Potential Sites in the Wolf River Basin comprise more than 500,000 acres. Some of these sites are difficult to access and traverse, making coverage of large areas difficult. The rail surveys conducted by interns lead me to wonder whether NHI would benefit from experienced birders who might volunteer their time. One possibility is to make future inventory project boundaries available on the Bureau of Endangered Resources (BER) webpage, and request sightings of rare birds from volunteers via the WisBirdNet (see http://www.uwgb.edu/birds/wso/ for more information). Theoretically, submissions of potential element occurrences from volunteers could be confirmed by BER staff, who are focusing on other areas.

Acknowledgments

I appreciate the assistance of several DNR staff during my surveys. Eric Roers, James Robaidek, Kay Brockman-Mederas and two interns from UW-Stevens Point provided logistical support for surveys of the Navarino SWA and nearby areas. Paul Samerdyke assisted in a canoe survey of the Wolf River, from Shaw Landing to Gills Landing.

References

Epstein, E., W. Smith, and A. Galvin. 2000. Biotic inventory & analysis of the Wolf River Basin: an interim report. Bureau of Endangered Resources, Wisconsin Department of Natural Resources.

Table 1. Scientific Names of Birds Mentioned

Common Name	Scientific Name
Great blue heron	Ardea herodias
American bittern	Botaurus lentiginosus
Red-shouldered hawk	Buteo lineatus
Black tern	Chlidonias niger
Northern harrier	Circus cyaneus
Yellow-billed cuckoo	Coccyzus americanus
Common moorhen	Gallinula chloropus
Red-headed woodpecker	Melanerpes erythrocephalus
Black-crowned night-heron	Nycticorax nycticorax
Osprey	Pandion haliaetus
Prothonotary warbler	Protonotaria citrea
King rail	Rallus elegans

APPENDIX J

A Synoptic Survey Of The Fishes Of The Lower Wolf River, Wisconsin

Submitted by John Lyons, Wisconsin DNR, March 2002.

Abstract

The lower Wolf River, flowing 101 miles from the Shawano Dam to Lake Poygan in northeastern Wisconsin, is one of the longest unimpounded warmwater river reaches remaining in the midwestern United States, but has never had a comprehensive fish survey. Seine or electrofishing samples were collected from 102 sites from 1997-2001 to characterize the fish fauna of the Lower Wolf. A total of 13,992 fish in 69 species and 18 families were collected, including 12 species not previously reported from the river. One of these species, channel shiner Notropis wickliffi, *has not been reported before from the Great Lakes basin. Three state-threatened species, speckled chub* Macrhybopsis aestivalis*, river redhorse* Moxostoma carinatum*, and greater redhorse*, Moxostoma valenciennesi*, and four special- concern species, lake sturgeon* Acipenser fulvescens, *weed shiner* Notropis texanus*, pugnose minnow* Opsopoeodus emiliae*, and western sand darter* Ammocrypta clara *were found. The most frequently encountered and common species were spotfin shiner* Cyprinella spiloptera*, emerald shiner* Notropis atherinoides*, sand shiner* Notropis stramineus*, bluntnose minnow* Pimephales notatus*, and johnny darter* Etheostoma nigrum. *The most frequently encountered and common gamefish were northern pike* Esox lucius, *bluegill* Lepomis macrochirus*, smallmouth bass* Micropterus dolomieu*, largemouth bass* Micropterus salmoides*, and yellow perch* Perca flavescens. *Individual species distributions and multivariate measures of fish assemblage composition showed few consistent patterns over the length of the study reach, but differed between off-channel (sloughs and backwaters) and main-channel habitats. Index of biotic integrity scores based on fish assemblages indicated that the overall environmental quality of the study reach was good. However, scores from survey sites with natural shorelines were significantly higher than scores from sites with 5-35% of their length stabilized with rock rip-rap.*

Introduction

The Wolf River supports some of the best-known and most-valuable river fisheries in Wisconsin and the Midwest. The upper river in Langlade County is nationally famous for trout fishing and is also an important white-water canoeing and rafting destination (Ross 1999). The lower river below the Shawano Dam is one of the longest unimpounded warmwater river reaches in the midwestern United States and has a largely intact floodplain with a wide variety of aquatic habitats. These habitats provide spawning grounds for large spring runs of walleyes and white bass (see Table 1 for scientific names of fishes) that draw many anglers (Preigel 1968, 1970a, 1970b). This spawning in turn supports major fisheries downstream in lakes Poygan, Winneconne, Butte des Morts, and Winnebago. Similarly, the lower Wolf is a major spawning and nursery area for the largest remaining lake sturgeon fishery in the United States (Folz and Myers 1985; Kempinger 1988; Lyons and Kempinger 1992).

Despite the importance of these fisheries, there has never been a comprehensive survey of the fishes of the Wolf River. Statewide and regional fish surveys (Greene 1935; Becker 1976, 1983; Fago 1992; Lyons et al. 2000a) have included data from the Wolf River, but the number of sampling sites has been limited and a list of species for the river has not been presented. Previous Wisconsin Department of Natural Resources surveys of the river have focused on selected gamefish species to the exclusion of most non-game fishes.

In the paper I summarize results of a synoptic survey of the fishes of the lower Wolf River. I report on the occurrence and abundance of all species and characterize the large-scale distribution patterns of selected species and assemblages of species. I also use a fish-based index of biotic integrity to assess the overall environmental quality of the river.

Study Area

The fish survey covered the 101 miles of the lower Wolf River from Lake Poygan, Winnebago County (River Mile (RM) = 0.0), upstream to the Shawano Dam, Shawano County (RM 101.0), Wisconsin (Figure 1). This reach is free-flowing with no barriers to block fish movement. There are three main tributaries, the Embarrass (RM 32.1), Little Wolf (RM25.9), and Waupaca (RM 13.4) rivers, and at least 20 smaller tributaries. At New London (RM 32.0), just below the mouth of the Embarrass River, the Wolf River has a drainage area of 2,260 square miles and a mean annual flow of 1,770 cubic feet per second (Garn et al. 2001). At the Shawano Dam the drainage area is 816 square miles and mean annual flow is 763 cubic feet per second. For the entire reach, summer water conductivities typically range from 240-360 *u*S, and maximum water temperature exceeds 27 C (Lyons, unpublished data). The water is generally stained a tea color from organic acids and is slightly to moderately turbid from suspended sediment during summer baseflows.

The character of the lower Wolf River changes over its length. For the first 10 miles or so below the Shawano Dam the river has a relatively narrow floodplain and few off-channel aquatic habitats such as sloughs, oxbows, and backwaters. The river is 50 to 75 m wide with a mean thalweg depth of 1-2 m (Lyons, unpublished data). A few deep riffles and shallow fast runs are present. Bottom substrates are predominately sand and gravel with areas of cobble and some boulders. Extensive macrophyte beds develop in the summer in some shallow areas. Abundance of large woody debris in the channel is low to moderate. The shoreline is mainly upland shrubs and forest. Rock rip-rap is uncommon.

For the remainder of its length, the Wolf River flows through a much wider and largely intact floodplain with extensive off-channel habitats. From 10 to 75 miles below the dam, the river is typically 25-50 m wide with mean thalweg depths of 2-4 m. Riffles are absent and shallow fast runs scarce, although occasional mid-channel, shallow, sand “flats” are present. Bottom substrates are sand, silt, and clay, and naturally occurring rock is rare. Macrophytes are common in off-channel habitats but uncommon in the main-channel. Large woody debris is common in both main- and off-channel habitats. The shoreline is mainly swamp forest with sand/clay banks, but the outside of many bends has been stabilized with boulder rip-rap, especially near towns, bridges, and fishing shacks. For the last 25 miles, below the mouth of the Little Wolf River, the river widens to 70-80 m and remains 2-4 m deep. Several large side channels with significant flow are present (e.g., Big Cut, Mill Cut) and there are two small main-channel lakes, Partridge and Partridge Crop. Silt and clay substrate dominates, but some sand is present. Macrophytes and large woody debris are common in both main and off-channel habitats. The shoreline is a mix of swamp forest and open marsh, with marsh predominating in the last 10 miles. Many banks have been stabilized with rip-rap.

Methods

Sampling took place during daylight between late May and late September from 1997-2001, with 98% of the sampling in 2000 and 2001. I chose the 102 sampling sites to cover the entire length of the lower Wolf River and to encompass all of the major habitat types that were present.

I used two sampling methods, seining and boat electrofishing. Two seines and three seining techniques were employed depending on habitat conditions. In riffles and fast runs, a 3 X 2 m seine with 6.4 mm delta mesh was set in place in the current and then the substrate upstream was disturbed by kicking to drive fish into the net. In deeper and slower main-channel areas, either this same seine or a larger 11 X 1.5 m bag seine with 6.4 mm delta mesh was pulled downstream with the current along the bank or in mid-channel on sand flats in water less than 1.2 m deep. In off-channel areas, which had little or no current, either of the same two seines was used, and each was pulled directly into shore from deeper water. For each seine haul, the total surface area seined was recorded. Two to five seine hauls were made at each sampling site, and 67 sites were seined (51 main-channel; 16 off-channel). All captured fishes were identified and counted, and then nearly all were released, except for a few specimens preserved as vouchers (deposited at the University of Wisconsin Zoological Museum, Madison) to confirm identifications.

Boat electrofishing involved a standard Wisconsin Department of Natural Resources “mini-boom” shocker and followed operating procedures and power settings recommended by Lyons et al. (2001). At 20 of the 23 main-channel sites shocking proceeded in a downstream direction along the bank and covered 1610 m (1 mile) of contiguous shoreline. The length of the shoreline with rock rip-rap was noted during this sampling. At the three remaining main-channel sites, shorter distances (100-500 m) were sampled to focus on species associated with rock rip-rap habitat. At the 12 off-channel sites, shocking also followed the shoreline, but the distance covered varied from 200 to 2000 m depending on the size of the site. An attempt was made to collect all fish observed in each shocking run. All captured fish were identified and counted. Gamefish species were measured for total length. At main-channel sites, fish were also weighed in aggregate by species. Again, nearly all captured fish were released, except for a few preserved as vouchers.

I summarized and analyzed the catch data by sampling site. Total catches and frequencies of occurrence of each species were then calculated for all sites combined. For those species that occurred at more than 5% of either the seining or shocking sites (”common species”), I calculated catch-per-unit-effort (CPUE) – either the number per m^2 seined or the number per 100 m of shoreline shocked.

Three analyses were conducted on the common species. These analyses were run separately for the seining and electroshocking data sets, and differences were considered significant if $P < 0.10$. First, I determined whether there were longitudinal patterns in the distribution of individual species along the length of the river. Each site was designated by a river mile value, and for each common species the mean and range of the river mile at which the species occurred was determined. A wide range with a mean river mile near 50 indicated that the species was found throughout the length of the river, whereas a narrow range or a mean much greater or less than 50 indicated a distribution concentrated in a specific part of the river.

Second, I compared the frequency of occurrence and abundance for each of the common species between main- and off-channel habitats. For frequency of occurrence, I carried out a chi-square test of the hypothesis that the species was equally likely to be encountered in the two habitat types (SAS 1990). Many species had limited occurrences and consequently the chi-square test had low statistical power, so to increase sample size, I also did the same analysis for the electroshocking and seining occurrences combined. For abundance, I did a t-test of CPUE between the two habitat types. Data were log-transformed to better approximate normality before the analysis.

Third, I carried out the multivariate ordination technique non-metric multi-dimensional scaling (NMDS; McCune and Mefford 1999) to identify assemblages of fishes and examine their distribution in the river. Ordinations were run on log-transformed CPUE data. Two ordination axes were extracted in each analysis. These axes represented the relative similarity in fish assemblage composition among the sampling sites. A plot of axis scores indicated which sites had similar assemblages. I correlated axis score with species CPUE to understand which species were most important in determining variation among sites in fish assemblage composition. Species with similar correlation coefficients for a particular axis tended to have similar distribution and abundance patterns among the sites. I correlated site river mile with axis score to determine whether assemblages were ordered longitudinally along the length of the river. Axis scores were compared between main- and off-channel habitats to reveal whether assemblage composition differed between the two habitat types.

My final analysis involved all species but only used the main-channel electroshocking data. For each site, I calculated an index of biotic integrity (IBI) score following procedures described in Lyons et al. (2001). This score could range from 0 to 100, with a higher score indicating a better quality fish assemblage and, by implication, better environmental quality. I used a t-test to compare IBI scores from sites with natural shorelines to sites with rock rip-rap.

Results

Sampling of the lower Wolf River produced a large variety and number of fish. The 102 sites (74 main-channel, 28 off-channel) yielded 69 species and one hybrid in 18 families and a total of 13,992 fish (Table 1). Twelve species, shortnose gar, gizzard shad, river shiner, bigmouth shiner, channel shiner, creek chub, brown bullhead, troutperch, brook silverside, brook stickleback, green sunfish, and Iowa darter, had not been previously reported from the lower Wolf River. Eleven of these were known from other parts of the Wolf River system (tributaries or downstream or upstream lakes), but the channel shiner had never been reported before from anywhere in the Great Lakes basin

(Becker 1983; Lyons et al. 2000a). The most frequently encountered and numerous species were spotfin shiner, emerald shiner, sand shiner, bluntnose minnow, and johnny darter (Table 1). These five species made up 70% of the total catch. Conversely, 27 species were represented by five or fewer individuals. The most frequently encountered and numerous gamefish were northern pike, bluegill, smallmouth bass, largemouth bass, and yellow perch. A total of 40 species were designated as “common species”, 34 in the electrofishing dataset and 29 in the seining dataset. Seven species, mooneye, blackchin shiner, spottail shiner, lake chubsucker (special concern), yellow bullhead, brown trout , and white crappie had been reported from the lower Wolf River by previous authors but were not found during this study.

Seven species considered rare by the Wisconsin Department of Natural Resources were encountered during my sampling (Table 2). Three threatened species were collected: speckled chub, river redhorse, and greater redhorse. A single speckled chub was taken from a mid-channel sand bar in the upper part of the Lower Wolf, a representative of the only known population of this species in the Great Lakes basin (Lyons et al. 2000a). Five river redhorse were collected from main-channel shorelines in the middle and upper part of the study area, whereas four greater redhorse were taken from main-channel shorelines in the lower portion of the study area. Four special-concern species were found: lake sturgeon, weed shiner, pugnose minnow, and western sand darter. Two young-of-year and one adult lake sturgeon were encountered in the main-channel of the upper part of the study area. Nineteen weed shiners were collected from main- and off-channel habitats in the middle of the study reach, and five pugnose shiners were caught in a single off-channel site in the lower part of the reach. A total of 67 western sand darters were taken from six main-channel sites throughout most of the study area.
Most of the common species had broad distributions over the length of the lower Wolf River (Table 3). Results from the analyses of the electroshocking and seining datasets were similar. Of the 40 common species, 30 had a range of at least 70 river miles with mean river mile between 40 and 60. Four species, gizzard shad, channel shiner, bullhead minnow, and greater redhorse, were limited to the lower half of the study area, and another five, northern redbelly dace, northern hog sucker, river redhorse, banded darter, and blackside darter, mainly occurred in the upper half. The central mudminnow was found only in the middle third of the lower Wolf.

The common species had complex patterns of occurrence and abundance between main- and off-channel habitats (Table 4). Nine species – longnose gar, bowfin, gizzard shad, common shiner, emerald shiner, fathead minnow, white sucker, shorthead redhorse, and johnny darter – had no significant differences in frequency of occurrence and CPUE for either electroshocking or seining between main- and off-channel habitats. Ten species – northern redbelly dace, northern hog sucker, river redhorse, golden redhorse, greater redhorse, white bass, western sand darter, banded darter, logperch, and blackside darter – were significantly more frequently encountered and more numerous in main-channel habitats, and one species – central mudminnow – was encountered only in off-channel habitats. The remaining 20 species either had differences between occurrence and abundance patterns or between the electrofishing and seining datasets. Black crappies occurred more frequently at main-channel sites for the electrofishing dataset and at off-channel sites for the seining dataset. For both datasets, there was no difference in black crappie CPUE between the two habitat types. Ten species – common carp, golden shiner, bluntnose minnow, bullhead minnow, spotted sucker, northern pike, pumpkinseed, bluegill, largemouth bass, and yellow perch – had a combination of no difference between habitats and a greater value for off-channel habitats, depending on the type of measure (occurrence or abundance) and dataset considered. The remaining nine species – spotfin shiner, sand shiner, channel shiner, silver redhorse, channel catfish, rock bass, smallmouth bass, walleye, and freshwater drum – had both no difference and greater values for main-channel habitats. Thus, overall, nine species showed no differences in use of main- and off-channel habitats, 11 tended to use off-channel habitats more, 19 tended to use main-channel habitats more, and one, black crappie, had a more complex habitat use pattern.

The NMDS analyses demonstrated that habitat type and to a lesser extent longitudinal position in the Lower Wolf could account for much of the difference in fish assemblages among sites. For the electroshocking dataset, the two ordination axes explained 82% of the variation in species CPUE among the sites. Site scores were not significantly correlated with river mile for either axis, indicating that there was no consistent change in fish assemblages in an upstream or downstream direction. However, a plot of the site scores revealed that off-channel sites tended to have different assemblages than main-channel sites (Figure 2). Off-channel sites usually had low scores on axis two and high scores on axis one, whereas the opposite was true for main-channel sites. The species with relatively large negative correlations ($r > 0.33$) with the first axis, spotted sucker, golden shiner, yellow perch, and northern pike, were considered off-channel species (see previous paragraph). Those with large positive correlations, silver redhorse, emerald shiner, golden redhorse, and spotfin shiner, were mostly main-channel species or species, although the emerald shiner had no difference in habitat use between main- and off-channel habitats (Table 5). For the second axis, most of the large negative correlations were for main-channel species: smallmouth bass, rock bass, shorthead redhorse (no difference), freshwater drum, spotfin shiner, logperch, golden redhorse, northern hog sucker, channel catfish, and sand shiner. Most of the large positive correlations were for off-channel species: pumpkinseed, spotted sucker, yellow perch, bowfin (no difference), bluegill, and largemouth bass.

Results for the NMDS analysis of the seining dataset were somewhat similar but not as clear-cut. The two ordination axes explained 69% of the variation in species CPUE among sites. Site scores along the first axis were not significantly correlated with river mile, but scores on the second axis were negatively correlated ($r = -0.691$; $p < 0.01$). Thus, upstream sites tended to have lower scores along this axis than downstream sites, and therefore fish assemblages changed along the length of the study area. A plot of the site scores revealed that almost all off-channel sites had positive scores, whereas main-channel sites had both positive and negative scores (Figure 3). Main- and off-channel sites had little distinction along axis one, although main-channel sites had the lowest and highest scores. Therefore, overall, off-channel sites had a narrower range of fish assemblages than main-channel sites. The only species with a large positive correlation with axis one was northern pike, an off-channel species, whereas fishes with large negative correlations were a mix of the "no difference" species emerald shiner and white sucker, the off-channel species bullhead minnow, and the main-channel species sand shiner and channel shiner (Table 5). For axis two, the three fishes with large negative correlations were all main-channel species. One, sand shiner, was widespread, but the other two, northern hog sucker and banded darter, were found mainly in the upper half of the study area. Of the nine fishes with large negative correlations, seven, bluegill, bluntnose minnow, largemouth bass, golden shiner, pumpkinseed, and northern pike, were off-channel species, one, johnny darter, was a no difference species, and one, channel shiner, was a main-channel species. The channel shiner was only encountered in the lower half of the study area.

Based on IBI scores, environmental quality was variable but generally good over the entire study area (Table 6). For the 20 main-channel sites analyzed, mean IBI score was 67 with a rating of good, with a range of scores from 40 to 95 and a range of ratings from fair to excellent. Scores were not correlated with river mile, but were related to the presence of rock rip-rap on the bank. Sites with at least some rip-rap (5-35% of site length) had a mean score of 58 and a rating of fair, which was significantly lower ($t = 3.332$; $p = 0.0037$) than the mean of 75 and rating of good for sites without rip-rap. Of the 10 sites with rip-rap, four rated as fair and six as good, whereas of the 10 sites without rip-rap six rated as good and four as excellent. Thus, fish assemblage quality and, by inference, environmental quality did not change consistently over the length of the study area but were generally lower at sites with rip-rapped banks.

Discussion

The lower Wolf River supports a diverse fish fauna. Seventy-six species have been found in this river reach, 69 during this study. Most of these species are native inhabitants of the river, but some are likely present in the river only as strays from small tributaries and others have been introduced. Brassy minnow, northern redbelly dace, creek chub, and brook stickleback are native species characteristic of small streams and are usually absent from large rivers (Lyons 1996). In this study they were caught only near the mouths of small tributaries, so they were probably strays. Common carp and brown trout were both brought to Wisconsin waters in the late 1800s from Europe and have become widely established in the state, including the Wolf River drainage (Becker 1983). The brown trout is incapable of completing its life cycle in a river as warm as the lower Wolf, so its presence there is as a stray from a colder tributary or further upstream in colder reaches of the upper Wolf River. Muskellunge are native to Wisconsin, but not to the Wolf River drainage. They currently are widely stocked in Wisconsin waters including the Wolf. The origin of 10 species – shortnose gar, gizzard shad, speckled chub, river shiner, channel shiner, pugnose minnow, bullhead minnow, western sand darter, slenderhead darter, and river darter – is unclear. All are characteristic of large rivers in the Mississippi River basin but have distributions in the Lake Michigan basin that are essentially limited to the Fox-Wolf River drainage (in some cases also including lower Green Bay or its tributary the Menominee River; Lyons et al. 2000a). Becker (1976, 1983) suggested that at least some of these species may be non-native to the Fox-Wolf, having perhaps invaded the Lake Michigan basin from the Mississippi River basin only recently via a canal built in the 1800's between the Wisconsin River (Mississippi basin) and the upper Fox River at Portage. However, a regular flood connection between the Wisconsin and Fox rivers at Portage prior to construction of the canal provided a ready mechanism for natural colonization of these and other fishes from the Mississippi basin over the last several thousand years, making them possibly native to the lower Wolf (Becker 1983; Lyons et al. 2000a).

The rich diversity of the fish fauna and the presence of at least seven rare fishes indicate that the Lower Wolf has great ichthyological value above and beyond its fisheries. Conservation of the rare fishes is particularly important. As mentioned, the lower Wolf River speckled chub population is the only one of its kind in the entire Great Lakes basin. The only Great Lakes basin populations of the western sand darter occur in the Wolf, Embarrass, Waupaca, and Menominee rivers (Lyons et al. 2000a). Of these four, the lower Wolf River appears to support the largest number of individuals (Lyons, unpublished data). The lake sturgeon occurs throughout the Great Lakes basin, but the Wolf River likely has the greatest reproduction of any river in the basin (Folz and Myers 1985). The pugnose minnow has been reported from the Lake Michigan basin only from the Fox-Wolf River drainage and from Wolf Lake in northeastern Illinois, where it no longer occurs (Becker 1976). Becker (1976, 1983) believed river redhorse to be extirpated from the Lake Michigan basin, but recent surveys confirm their presence in the lower Wolf (Fago 1992; Lyons et al. 2000a; this study), and Fox (Lyons et al. 2000a) rivers in Wisconsin, the St Joseph River in southwestern Michigan and north-central Indiana (Wesley and Duffy 1999), and the Muskegon River in west-central Michigan (O'Neal 1997). The channel shiner, although not rare in the Mississippi basin of Wisconsin (Lyons et al. 2000a), has its only population in the entire Great Lakes basin in the lower Wolf River. Earlier surveys (e.g., Fago 1992) may have confused channel shiners in the lower Wolf with the very similar mimic shiner, which also occurs there.

The habitat designations of species from this study generally agree with literature accounts of their habitat preferences. Of the five species limited to the upper half of the lower Wolf, three, northern hog sucker, banded darter, and blackside darter, are usually encountered only in rocky riffles and fast runs (Becker 1983; Lyons 1996). These two habitat types were rare outside of the upper part of the study area. Two of the species limited to the lower half, channel shiner and bullhead minnow, are characteristic of the largest rivers in the state and are rarely encountered in reaches with a watershed area of less than 1500 square miles (Lyons et al. 2000a, 2001; Lyons, unpublished data). Only the lower portion of the study area was this large. Many of the species designated as primarily using the main-channel in the lower Wolf, including sand shiner, channel shiner, northern hog sucker, silver redhorse, river redhorse, western sand darter, banded darter, and blackside darter, are riverine specialists that require flowing water habitats (Lyons et al. 2001). Conversely, most of the off-channel species, such as common carp, golden shiner, central mudminnow, northern pike, pumpkinseed, bluegill, largemouth bass, and yellow perch, are species of low-gradient streams with limited current and of lakes (Becker 1983; Lyons 1996). Much of the off-channel habitat in the lower Wolf was lake-like in character. Many of the species that used both main- and off-channel habitats, such as common shiner, emerald shiner, white sucker, and shorthead redhorse, are considered habitat generalists (Becker 1983; Lyons et al. 2000a).

Habitat type (main-channel vs. off-channel) was more important than longitudinal position in explaining the distribution of individual fish species and assemblages in the lower Wolf River, a finding that agrees with current ideas about the relative importance of longitudinal versus lateral processes in lowland rivers. Of the 40 common species, only 10 were limited to a particular longitudinal portion of the lower Wolf with the remainder found over most or all of the length of the study area. Conversely, 31 of the common species had a distribution pattern than favored either main- or off-channel habitats. For the electroshocking dataset, similarities among fish assemblages could be explained by habitat type but not by longitudinal position, whereas for the seining dataset, assemblage similarity was explained both by habitat type and by longitudinal position. Recent theories concerning the structure and function of large floodplain rivers postulate that physical, chemical, and biological characteristics often change more in moving a few hundred meters laterally from channel to floodplain habitats than they do in moving longitudinally up or down the channel for tens of thousands of meters (Junk et al. 1989). Consequently, biological assemblages are predicted to differ more between adjacent main- and off-channel aquatic habitats than between widely separated main-channel habitats. Findings for lower Wolf River fishes are consistent with this prediction.

Fish assemblage data document that the environmental quality of the lower Wolf River is generally good. This is likely due in large part to the intact floodplain, the absence of substantial point- or non-point-source pollution in the watershed, and the lack of dams or other major hydrologic works to fragment the river and modify habitat (Lyons et al. 2001). Most large warmwater rivers in the midwestern United States are far more degraded than the lower Wolf (e.g., Karr et al. 1985; Fremling et al. 1989), another indication of the great ecological value of the river. However, because IBI ratings average good rather than excellent, the environmental quality of the lower Wolf could perhaps be improved.

One human activity that is problematic in the lower Wolf River is rip-rapping of the river banks. Certainly some of this rip-rapping is necessary to protect important public works such as bridges or roadbeds, and rip-rapping has increased lake sturgeon spawning habitat (Folz and Myers 1985). However, IBI scores and fish assemblage quality along banks with rip-rap are significantly lower than scores and assemblages along natural banks, indicating that the net effect of rip-rapping on the river ecosystem may be negative. My field observations suggest that these fish assemblage and IBI differences are related to the relative amounts of large woody debris in the water along the two types of banks. Along natural banks, normal processes of bank erosion and lateral channel migration gradually undermine the root structure of bankside trees, eventually causing them to fall into the river (Gordon et al. 1992). This important natural phenomenon is most pronounced on the outside of bends, where erosive forces and channel migration are greatest. Downed trees provide excellent habitat for a wide range of species and typically support a high density and biomass of fish (Lyons et al. 2000b). However, along rip-rapped banks, erosion and channel migration are prevented, so natural recruitment of trees to the river is curtailed. Because rip-rapping is concentrated in areas where erosion (and thus tree recruitment) is highest, such as the outside of bends, relatively small amounts of rip-rapping – only 5-10% of bank length at some sites – can have disproportionately large effects on river habitat and hence river fish assemblages. The rip-rap itself does provide some habitat, particularly for species such as smallmouth bass and rock bass that favor rocky substrate. However, based on my observations, most rip-rap in the lower Wolf is out of the water at normal summer flows, and the small surface area of rocky habitat available to fish is usually much less than would have been provided by fallen trees. I recommend that future bank rip-rapping projects on the lower Wolf be critically examined to determine whether their benefits exceed their ecological costs.

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Table J-1. List of species captured from the lower Wolf River. Number of sites and fish refer to this study; species with a zero catch have been reported previously from the lower Wolf River but were not encountered in this study. Species followed by an "S" (seining) or an "E" (electrofishing) in parentheses were "common species" (encountered at more than 5% of the seining or electrofishing sites) and were used in quantitative analyses.

Common Name	**Scientific Name**	**Number of sites**	**Number of fish**
LAMPREYS	PETROMYZONTIDAE		
Silver Lamprey	*Ichthyomyzon unicuspis*	1	1
STURGEONS	ACIPENSERIDAE		
Lake Sturgeon	*Acipenser fulvescens*	3	3
GARS	LEPISOSTEIDAE		
Longnose Gar (E)	*Lepisosteus osseus*	9	11
Shortnose Gar	*Lepisosteus platostomus*	1	1
BOWFINS	AMIIDAE		
Bowfin (E)	*Amia calva*	12	17
HERRINGS	CLUPEIDAE		
Gizzard Shad (E, S)	*Dorosoma cepedianum*	18	309
MOONEYES	HIODONTIDAE		
Mooneye	*Hiodon tergisus*	0	0
MINNOWS	CYPRINIDAE		
Common Carp (E)	*Cyprinus carpio*	28	168
Spotfin Shiner (E, S)	*Cyprinella spiloptera*	68	1936
Brassy Minnow	*Hybognathus hankinsoni*	1	2
Common Shiner (S)	*Luxilus cornutus*	9	25
Speckled Chub	*Macrhybopsis aestivalis*	1	1
Hornyhead Chub	*Nocomis biguttatus*	2	4
Golden Shiner (E, S)	*Notemigonus crysoleucas*	25	195
Emerald Shiner (E, S)	*Notropis atherinoides*	65	2625
River Shiner	*Notropis blennius*	3	4
Bigmouth Shiner	*Notropis dorsalis*	2	6
Blackchin Shiner	*Notropis heterodon*	0	0
Blacknose Shiner	*Notropis heterolepis*	2	2
Spottail Shiner	*Notropis hudsonius*	0	0
Rosyface Shiner	*Notropis rubellus*	4	10
Sand Shiner (E, S)	*Notropis stramineus*	37	2558
Weed Shiner	*Notropis texanus*	3	19
Mimic Shiner	*Notropis volucellus*	4	19
Channel Shiner (E, S)	*Notropis wickliffi*	23	482
Pugnose Minnow	*Opsopoeodus emiliae*	1	5

Table J-1 - Continued.

Common Name	Scientific Name	Number of sites	Number of fish

Northern Redbelly Dace (S)	*Phoxinus eos*	5	13
Bluntnose Minnow (E, S)	*Pimephales notatus*	52	2077
Fathead Minnow (S)	*Pimephales promelas*	13	40
Bullhead Minnow (E, S)	*Pimephales vigilax*	15	430
Creek Chub	*Semotilus atromaculatus*	1	45
SUCKERS	CATOSTOMIDAE		
Quillback	*Carpiodes cyprinus*	2	2
White Sucker (E, S)	*Catostomus commersoni*	21	218
Lake Chubsucker	*Erimyzon sucetta*	0	0
Northern Hog Sucker (E, S)	*Hypentelium nigricans*	9	96
Spotted Sucker (E, S)	*Minytrema melanops*	30	123
Silver Redhorse (E, S)	*Moxostoma anisurum*	28	216
River Redhorse (E)	*Moxostoma carinatum*	3	5
Golden Redhorse (E)	*Moxostoma erythrurum*	18	74
Shorthead Redhorse (E)	*Moxostoma macrolepidotum*	31	206
Greater Redhorse (E)	*Moxostoma valenciennesi*	4	4
BULLHEAD CATFISHES	ICTALURIDAE		
Black Bullhead	*Ameiurus melas*	2	5
Yellow Bullhead	*Ameiurus natalis*	0	0
Brown Bullhead	*Ameiurus nebulosus*	1	1
Channel Catfish (E)	*Ictalurus punctatus*	15	32
Tadpole Madtom	*Noturus gyrinus*	1	1
Flathead Catfish	*Pylodictis olivaris*	2	2
PIKES	ESOCIDAE		
Northern Pike (E, S)	*Esox lucius*	36	109
Muskellunge	*Esox masquinongy*	2	2
MUDMINNOWS	UMBRIDAE		
Central Mudminnow (S)	*Umbra limi*	9	76
TROUTS	SALMONIDAE		
Brown Trout	*Salmo trutta*	0	0
TROUT-PERCHES	PERCOPSIDAE		
Trout-perch	*Percopsis omiscomaycus*	1	2
CODFISHES	GADIDAE		
Burbot	*Lota lota*	2	3
SILVERSIDES	ATHERINIDAE		

Table J-1 - Continued.

Common Name	Scientific Name	Number of sites	Number of fish
Brook Silverside	*Labidesthes sicculus*	1	2
STICKLEBACKS	GASTEROSTEIDAE		
Brook Stickleback	*Culaea inconstans*	3	3

TEMPERATE BASSES	PERCICHTHYIDAE		
White Bass (E)	*Morone chrysops*	4	4
SUNFISHES	CENTRARCHIDAE		
Rock Bass (E, S)	*Ambloplites rupestris*	27	105
Green Sunfish	*Lepomis cyanellus*	2	2
Green Sunfish X Unknown Sunfish	*Lepomis cyanellus x Lepomis* sp.	1	1
Pumpkinseed (E, S)	*Lepomis gibbosus*	19	69
Bluegill (E, S)	*Lepomis macrochirus*	50	197
Smallmouth Bass (E, S)	*Micropterus dolomieu*	29	221
Largemouth Bass (E, S)	*Micropterus salmoides*	33	95
White Crappie	*Pomoxis annularis*	0	0
Black Crappie (E, S)	*Pomoxis nigromaculatus*	19	50
PERCHES	PERCIDAE		
Western Sand Darter (S)	*Ammocrypta clara*	6	67
Iowa Darter	*Etheostoma exile*	3	3
Fantail Darter	*Etheostoma flabellare*	3	4
Johnny Darter (E, S)	*Etheostoma nigrum*	51	532
Banded Darter (E, S)	*Etheostoma zonale*	9	73
Yellow Perch (E, S)	*Perca flavescens*	28	98
Logperch (E, S)	*Percina caprodes*	13	20
Blackside Darter (S)	*Percina maculata*	9	68
Slenderhead Darter	*Percina phoxocephala*	4	4
River Darter	*Percina shumardi*	1	1
Walleye (E)	*Stizostedion vitreum*	15	43
DRUMS	SCIAENIDAE		
Freshwater Drum (E)	*Aplodinotus grunniens*	25	95

Table J-2 – Collection information for state-threatened and special-concern fishes encountered during this study.

Species	River Mile	Coordinates	Date	Habitat	Number
Threatened					
Speckled chub	96.2	44°43’56” N 88°33’59” W	1 June 2000	Main-channel sand flat	1
River redhorse	46.6	44°22’13” N 88°36’56” W	9 August 2000	Main-channel rip-rap bank	1
River redhorse	49.8	44°23’27” N 88°35’39” W	7 July 2000	Main-channel rip-rap bank	1
River redhorse	97.8	44°44’45” N 88°35’2” W	1 June 2000	Main-channel natural bank	3
Greater redhorse	16.9	No data No data	5 Sept. 1997	Main-channel natural bank	1
Greater Redhorse	21.2	44°21’0” N 88°50’23” W	7 Sept. 2000	Main-channel natural bank	1
Greater redhorse	29.3	44°23’56” N 88°46’46” W	11 August 2000	Main-channel natural bank	1
Greater redhorse	33.1	No data No data	9 Sept. 1998	Main-channel natural bank	1
Special concern					
Lake sturgeon	89.1	44°40’2” N 88°35’32” W	28 June 2001	Main-channel sand flat	1 juvenile
Lake sturgeon	96.2	44°43’56” N 88°33’59” W	1 June 2000	Main-channel sand flat	1 juvenile
Lake sturgeon	101.0	44°46’26” N 88°37’15” W	2 June 2000	Shawano Dam tailwater	1 adult
Weed shiner	38.2	44°21’41” N 88°40’48” W	10 August 2000	Weedy backwater	15
Weed shiner	63.0	44°30’19” N 88°34’38” W	27 Sept 2001	Main-channel sand-silt shore	1

Table J-2 – Continued.

Species	River Mile	Coordinates	Date	Habitat	Number

Weed shiner	67.5	44°32’12” N 88°33’31” W	27 Sept 2001	Mouth of small slough	3
Pugnose minnow	22.8	44°21’57” N 88°49’17” W	10 August 2000	Marshy slough	5
Western sand darter	24.4	44°21’38” N 88°48’57” W	6 Sept. 2000	Main-channel sand shoreline	23
Western sand darter	43.9	44°22’0” N 88°38’3” W	9 August 2000	Main-channel sand shoreline	3
Western sand darter	51.0	44°23’55” N 88°35’6” W	7 July 2000	Main-channel sand shoreline	5
Western sand darter	80.6	44°37’23” N 88°37’59” W	28 June 2001	Main-channel sand shoreline	2
Western sand darter	91.2	44°40’55” N 88°34’49” W	31 May 2000	Main-channel sand shoreline	1
Western sand darter	96.2	44°43’56” N 88°33’59” W	1 June 2000	Main-channel sand flat	33

Table J-3 – Mean and range of the river mile (RM) of sites where common species were encountered..

	Electroshocking dataset			Seining dataset		
Species	Sites	Mean RM	Range RM	Sites	Mean RM	Range RM
Longnose gar	10	45.8	0.4-93.2	2	Insufficient data	
Bowfin	10	53.6	0.3-93.1	2	Insufficient data	
Gizzard shad	13	31.8	12.0-55.9	5	20.3	9.1-47.7
Common carp	27	43.5	0.4-101.0	1	Insufficient data	
Golden shiner	11	47.4	3.1-89.5	14	45.6	1.5-74.6
Spotfin shiner	19	53.5	12.0-97.9	49	54.5	9.1-101.0
Common shiner	1	Insufficient data		8	70.3	25.6-96.2
Emerald shiner	24	41.5	3.1-93.2	41	43.5	9.1-95.3
Sand shiner	8	70.9	52.6-97.9	29	58.7	10.3-101.0
Channel shiner	3	32.8	26.9-42.2	20	31.7	9.1-49.5
Northern redbelly dace	0	Insufficient data		5	90.0	73.4-101.0
Bluntnose minnow	13	57.5	17.0-97.9	39	47.4	9.1-101.0
Fathead minnow	2	Insufficient data		11	49.1	23.5-86.9
Bullhead minnow	5	23.7	17.0-36.1	10	27.5	10.3-62.0
White sucker	6	52.9	12.0-93.2	15	52.2	18.3-90.1
Northern hog sucker	4	91.8	84.9-97.8	5	94.8	90.9-99.1
Spotted sucker	21	45.7	0.4-101.0	9	31.8	10.3-47.7
Silver redhorse	23	47.2	3.1-97.9	5	40.5	20.4-78.7
River redhorse	3	64.7	46.6-97.8	0	Insufficient data	
Golden redhorse	17	52.3	3.1-97.9	1	Insufficient data	
Shorthead redhorse	28	44.6	0.4-101.0	3	Insufficient data	

Table J-3 – Continued.

	Electroshocking dataset			Seining dataset		

Species	Sites	Mean RM	Range RM	Sites	Mean RM	Range RM
Greater redhorse	4	25.2	16.9-33.1	0	Insufficient data	
Channel catfish	15	41.9	7.5-97.9	0	Insufficient data	
Northern pike	19	47.6	3.1-97.9	17	47.5	1.5-83.5
Central mudminnow	2	Insufficient data		7	51.0	35.0-73.4
White bass	4	18.2	3.0-29.3	0	Insufficient data	
Rock bass	21	53.4	1.9-101.0	6	65.1	8.5-99.2
Pumpkinseed	9	41.0	0.4-93.2	10	45.1	8.5-79.9
Bluegill	30	45.5	0.4-101.0	20	42.0	5.9-101.0
Smallmouth bass	21	49.6	1.9-101.0	8	44.5	5.9-92.4
Largemouth bass	15	39.9	1.9-93.2	18	37.7	1.5-83.5
Black crappie	12	42.4	3.1-93.2	7	50.2	22.9-99.7
Western sand darter	1	Insufficient data		5	59.2	24.4-96.2
Johnny darter	4	54.0	26.9-93.2	47	51.3	1.5-101.0
Banded darter	4	82.2	46.6-97.8	5	84.9	51.3-99.1
Yellow perch	18	42.4	0.4-93.2	10	38.9	10.3-56.5
Logperch	8	72.1	26.9-97.9	5	53.1	10.3-91.3
Blackside darter	2	Insufficient data		7	81.7	45.9-101.0
Walleye	15	52.7	3.1-97.9	0	Insufficient data	
Freshwater drum	25	48.0	1.9-101.0	0	Insufficient data	

Table J-4 – Type of habitat, either main- or off-channel, where common species most frequently occurred and were most abundant. "Both" indicates that there was no difference in occurrence or abundance between the two habitat types. An asterisk indicates that the number of occurrences was small and the chi-square test had low power.

	Electroshocking dataset		Seining dataset		Combined dataset
Species	Occurrence	Abundance	Occurrence	Abundance	Occurrence
Longnose gar	Both	Both	Insufficient data		Both
Bowfin	Both	Both	Insufficient data		Both
Gizzard shad	Both	Both	Both*	Both	Both
Common carp	Both	Off	Insufficient data		Both
Golden shiner	Both	Off	Off	Both	Off
Spotfin shiner	Main	Both	Both	Both	Both
Common shiner	Insufficient data		Both	Both	Both
Emerald shiner	Both	Both	Both	Both	Both
Sand shiner	Main*	Both	Both	Main	Main
Channel shiner	Main*	Main	Both	Both	Both
Northern redbelly dace	Insufficient data		Main*	Main	Main
Bluntnose minnow	Both	Both	Off	Both	Both
Fathead minnow	Insufficient data		Both	Both	Both
Bullhead minnow	Both*	Off	Both	Both	Both
White sucker	Both*	Both	Both	Both	Both
Northern hog sucker	Main*	Main	Main*	Main	Main
Spotted sucker	Both	Off	Both	Off	Off
Silver redhorse	Main	Main	Both*	Both	Main
River redhorse	Main*	Main	Insufficient data		Main*

Table J-4 – Continued.

	Electroshocking dataset		Seining dataset		Combined dataset
Species	Occurrence	Abundance	Occurrence	Abundance	Occurrence

Golden redhorse	Main	Main	Insufficient data		Main
Shorthead redhorse	Both	Both	Insufficient data		Both
Greater redhorse	Main*	Main	Insufficient data		Main*
Channel catfish	Main	Both	Insufficient data		Main
Northern pike	Both	Both	Off	Both	Both
Central mudminnow	Insufficient data		Off*	Off	Off*
White bass	Main*	Main	Insufficient data		Main*
Rock bass	Main	Both	Both*	Both	Main
Pumpkinseed	Both	Both	Off	Both	Off
Bluegill	Both	Off	Off	Off	Off
Smallmouth bass	Main	Both	Both	Both	Main
Largemouth bass	Both	Both	Off	Both	Off
Black crappie	Main	Both	Off	Both	Both
Western sand darter	Insufficient data		Main	Main	Main
Johnny darter	Both*	Both	Both	Both	Both
Banded darter	Main*	Main	Main*	Main	Main
Yellow perch	Both	Off	Both	Both	Off
Logperch	Main	Main	Main	Main	Main
Blackside darter	Insufficient data		Main	Main	Main
Walleye	Main	Both	Insufficient data		Main
Freshwater drum	Main	Both	Insufficient data		Main

TableJ- 5 – Correlations between the CPUE of the common species and ordination axis scores for the non-metric multi-dimensional scaling analysis. Values greater than 0.33 and less than –0.33 are in bold type.

	Electroshocking dataset		Seining dataset	
Species	Axis 1	Axis 2	Axis 1	Axis2
Longnose gar	0.261	-0.209	Not included in analysis	

Bowfin	-0.003	**0.417**	Not included in analysis	
Gizzard shad	0.158	0.104	-0.207	0.205
Common carp	0.189	-0.110	Not included in analysis	
Golden shiner	**-0.574**	0.321	-0.022	**0.367**
Spotfin shiner	**0.365**	**-0.481**	-0.017	0.010
Common shiner	Not included in analysis		-0.188	0.116
Emerald shiner	**0.594**	0.236	**-0.607**	**0.343**
Sand shiner	0.164	**-0.373**	**-0.447**	**-0.369**
Channel shiner	0.219	0.054	**-0.382**	**0.443**
Northern redbelly dace	Not included in analysis		-0.020	-0.259
Bluntnose minnow	-0.059	-0.021	-0.252	**0.489**
Fathead minnow	Not included in analysis		-0.208	0.133
Bullhead minnow	0.215	0.233	**-0.334**	0.245
White sucker	-0.067	0.085	**-0.395**	0.019
Northern hog sucker	0.040	**-0.407**	-0.036	**-0.410**
Spotted sucker	**-0.616**	**0.616**	-0.221	**0.384**
Silver redhorse	**0.608**	**-0.377**	-0.132	0.045
River redhorse	0.180	-0.295	Not included in analysis	
Golden redhorse	**0.414**	**-0.441**	Not included in analysis	

Table J-5 – Continued.

Species	Electroshocking dataset Axis 1	Axis 2	Seining dataset Axis 1	Axis 2
Shorthead redhorse	0.033	**-0.670**	Not included in analysis	
Greater redhorse	0.224	0.107	Not included in analysis	
Channel catfish	0.099	**-0.386**	Not included in analysis	
Northern pike	**-0.380**	-0.009	**0.446**	**0.331**

Central mudminnow	Not included in analysis		0.027	0.134
White bass	0.097	0.274	Not included in analysis	
Rock bass	-0.020	**-0.823**	0.327	0.093
Pumpkinseed	-0.151	**0.622**	0.096	**0.338**
Bluegill	-0.190	**0.402**	-0.002	**0.497**
Smallmouth bass	0.094	**-0.834**	-0.110	0.123
Largemouth bass	-0.101	**0.339**	-0.008	**0.423**
Black crappie	0.125	0.096	-0.066	0.202
Western sand darter	Not included in analysis		-0.083	-0.048
Johnny darter	0.171	0.148	-0.268	**0.381**
Banded darter	0.045	-0.312	-0.004	**-0.336**
Yellow perch	**-0.456**	**0.444**	-0.283	0.154
Logperch	0.177	**-0.454**	-0.007	-0.200
Blackside darter	Not included in analysis		0.030	-0.021
Walleye	0.252	-0.207	Not included in analysis	
Freshwater drum	-0.013	**-0.541**	Not included in analysis	

Table J -6. Index of biotic integrity (IBI) scores for main-channel sites on the lower Wolf River. River mile indicates the downstream end of the site.

River mile	IBI Score	Rating	Rip-rap?	Year	Month	Day
3.0	75	Good	Yes	2001	June	29
11.9	70	Good	Yes	2000	Sept.	7
16.9	85	Excellent	No	1997	Sept.	5
21.2	80	Excellent	No	2000	Sept.	7
26.8	65	Good	Yes	2000	Sept.	6
29.3	70	Good	No	2000	August	11
33.1	60	Good	Yes	1998	Sept.	9
35.5	40	Fair	Yes	2000	August	10
42.1	50	Fair	Yes	2000	August	10
46.6	65	Good	Yes	2000	August	9
49.8	65	Good	Yes	2000	July	7
52.5	60	Good	No	2000	July	5
57.3	70	Good	No	2000	July	6
59.5	50	Fair	Yes	2000	July	6
65.4	40	Fair	Yes	2001	Sept.	27
76.0	60	Good	No	2001	June	28
84.9	75	Good	No	2001	June	28
91.2	85	Excellent	No	2000	May	31
93.1	75	Good	No	1997	Sept.	5
97.8	95	Excellent	No	2000	June	1